ENGR4300
Fall 2005
Test 4A

Name_____solutions_____

Section_____

Question 1 (25 points)_____

Question 2 (25 points) _____

Question 3 (25 points)_____

Question 4 (25 points)_____

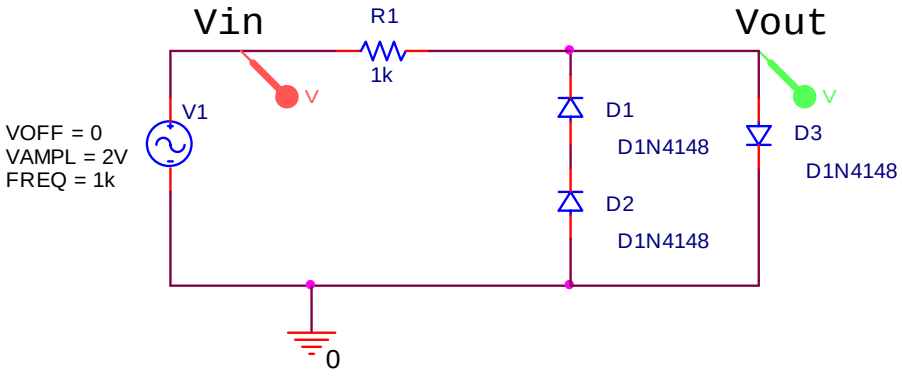
Total (100 points): _____

Please do not write on the crib sheets.

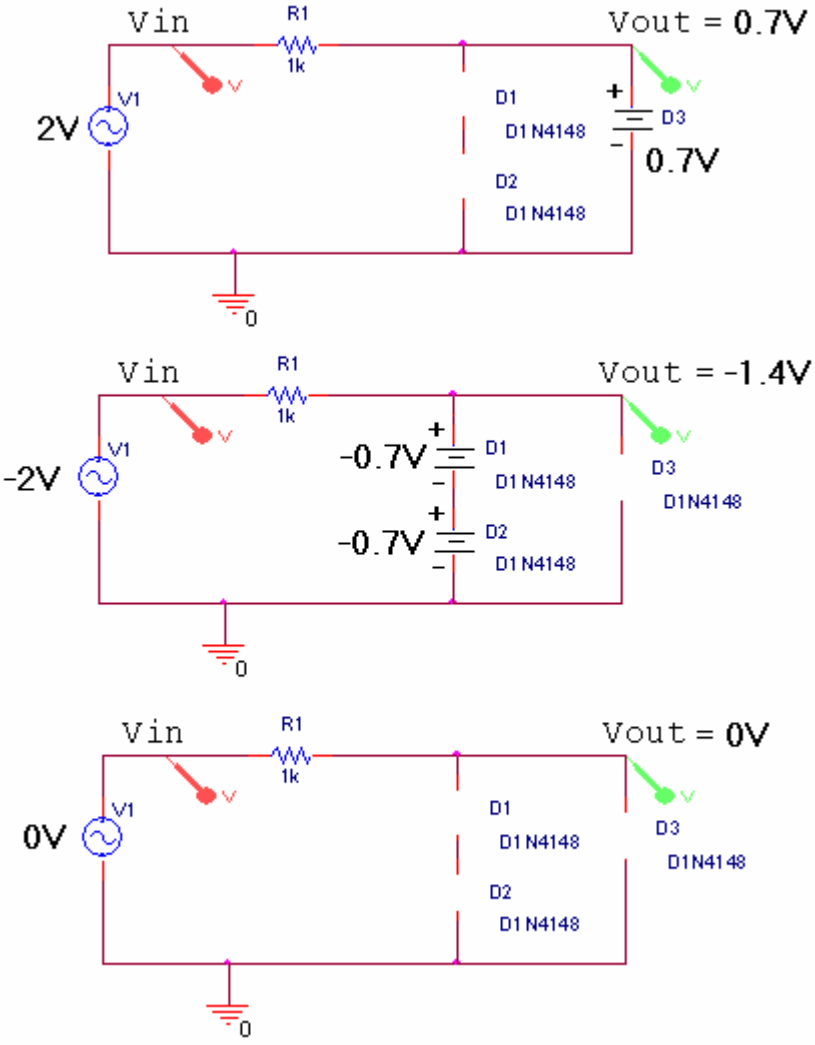
On all questions: SHOW ALL WORK. BEGIN WITH FORMULAS, THEN SUBSTITUTE VALUES AND UNITS. No credit will be given for numbers that appear without justification.

Question 1 – Diodes (25 points)

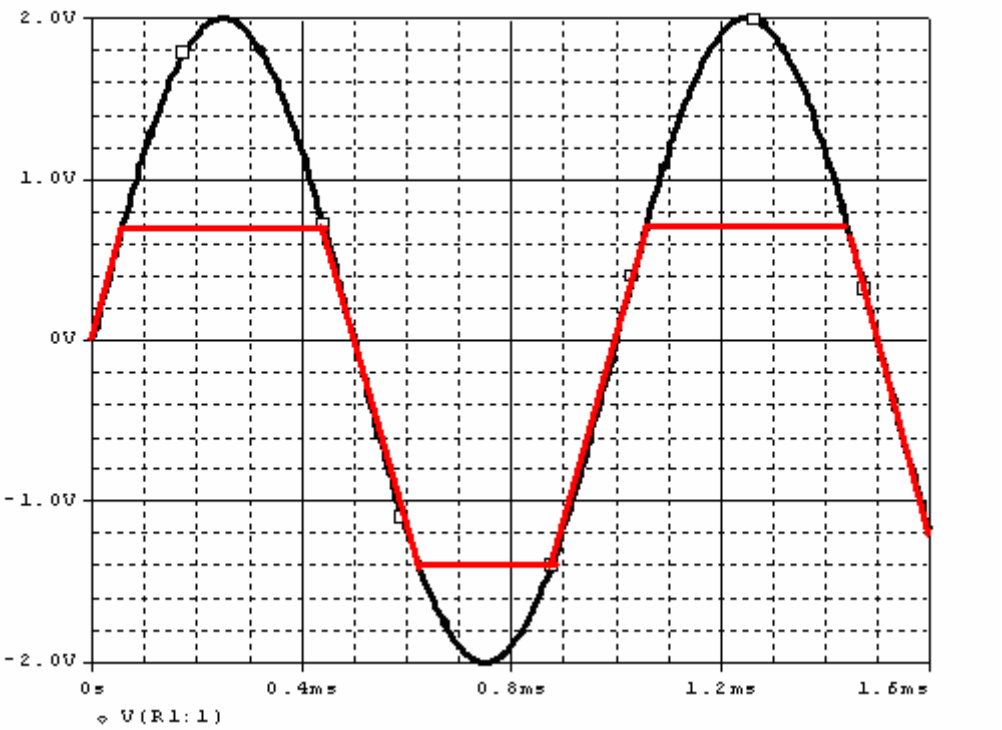
Part A: In the following circuit, assume that Von for all of the diodes is 0.7V.



A1) Redraw what the circuit looks like for each of the three input voltages below. Replace the diodes that are on with voltage sources and the diodes that are off with open circuits. Indicate the voltage value of Vout. (3 pt each = 9 pt)



A2) Sketch the output at Vout on this graph of Vin. (4 pt)



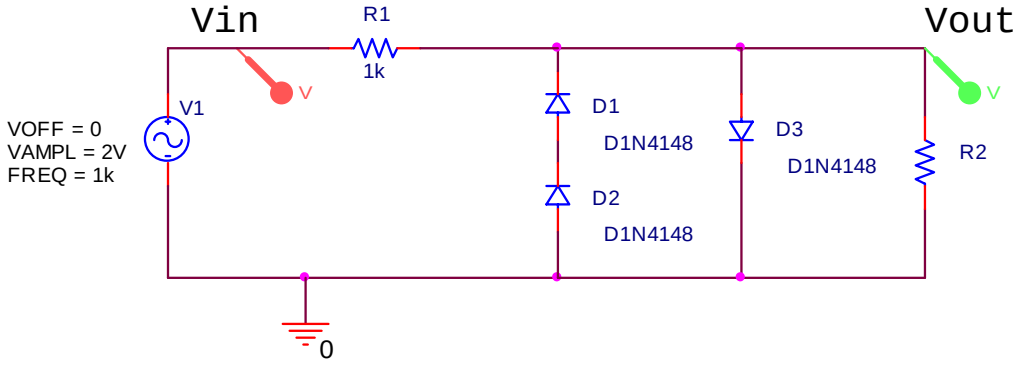
A3) What are the maximum and minimum *currents* through resistor R1? (4 pt)

$I_{R1} = (Vin-V_D)/1k$

maximum current: $I_{R1} = (2-0.7)/1k$ = ***1.3mA***

minimum current: $I_{R1} = (-2+1.4)/1k$ = ***-0.6mA***

Part B: We add a load resistor, R2, in parallel with the diodes, as shown below.

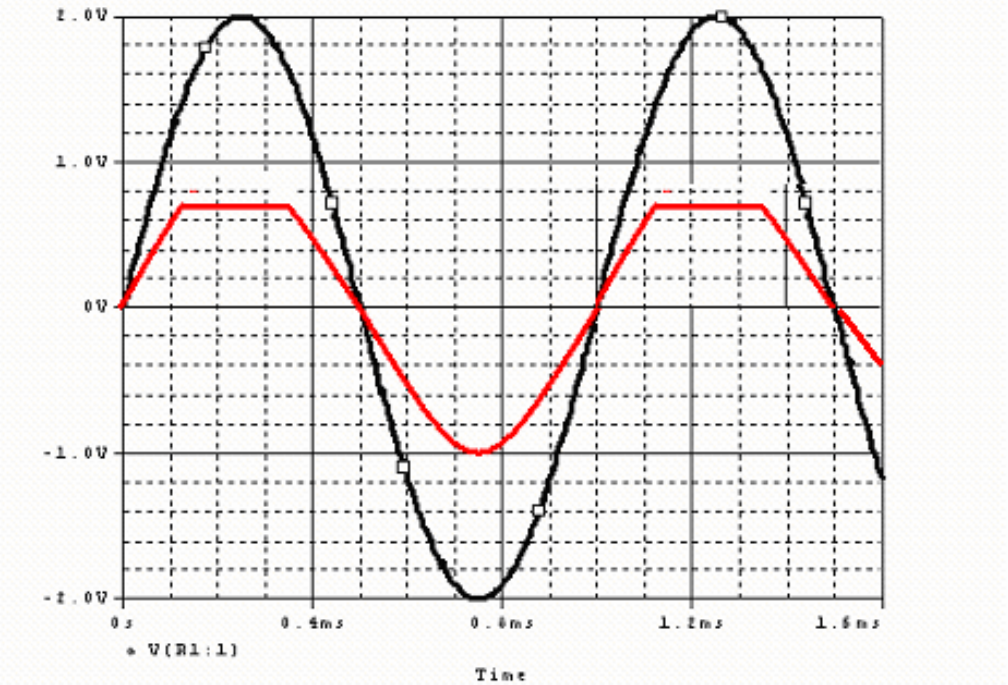


B1) If the load resistor is 1K Ω, what are the minimum and maximum *voltages* at Vout? (2 pt)

minimum voltage: *Wants to be at -2V(1k/(1k+1k))= -1V.*
This is above -1.4V, so the diodes will not turn on and
Vmin = -1V

maximum voltage: *Wants to be at +2(1k/(1k+1k))=+1V*
This is above +0.7V, so the diode will turn on and hold it to +0.7V.
Vmax = +0.7V

B2) Sketch Vout on the following graph of Vin for the load resistance of 1K Ω. (2 pt)

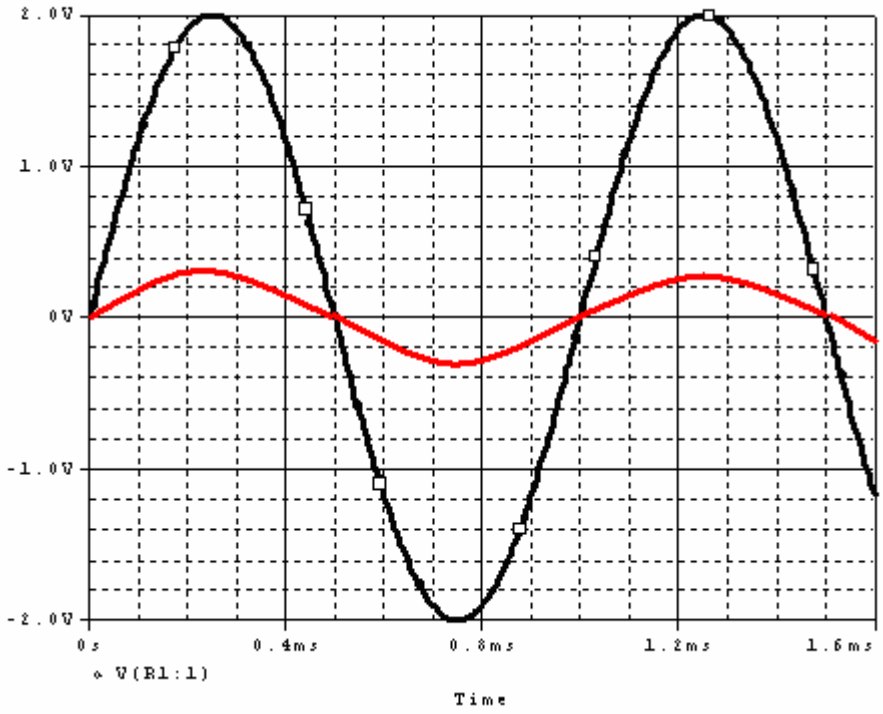


B3) If the load resistor is 200 Ω, what are the minimum and minimum *voltages* at Vout? (2 pt)

minimum voltage: *Wants to be at -2V(200/(200+1k)) = -0.333 Volts*
This is more than -1.4, so the diodes will be off.
Vmin = -0.333V

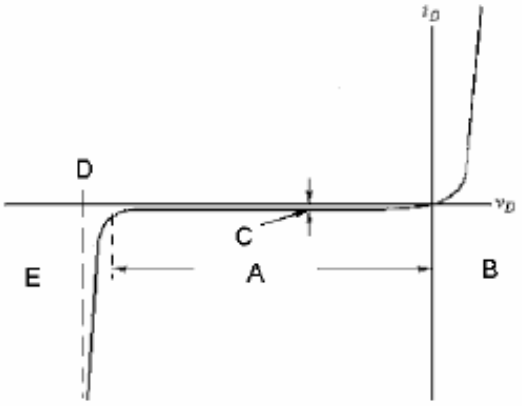
maximum voltage: *Wants to be at +2V(200/200+1k)) = +0.333 Volts*
This is less than +0.7, so the diodes will be off.
Vmax =+0.333V

B4) Sketch Vout on the following graph of Vin for the load resistance of 200 Ω. (2 pt)



Question 2 – Zener Diodes (25 points)

Part A: Zener Diode Characteristics



a) Identify the following as shown on the characteristic curve above, or indicate if it is not shown or non-existent (NA) (circle one) [4 points]:

Zener Region	A	B	C	D	***E***	NA
Forward Bias Region	A	***B***	C	D	E	NA
Asymptotic Current Region	A	B	C	D	E	***NA***
Reverse Bias Region	***A***	B	C	D	E	NA
Zener Voltage	A	B	C	***D***	E	NA
Forward Voltage Limit	A	B	C	D	E	***NA***
Operating Current	A	B	C	D	E	***NA***
Saturation Current	A	B	***C***	D	E	NA

b) You've worked with the 1N750 Zener Diode in the lab. What was its zener voltage? (circle one) [2 point]

0.7V 2.2V ***4.7V*** 9V 12V 13.7V 24V 75V 100V

c) What was its forward voltage drop (Von)? (circle one) [2 point]

0.7V 2.2V 4.7V 9V 12V 13.7V 24V 75V 100V

d) The junction in this zener diode and many other common diodes are made from the following: [1 point]

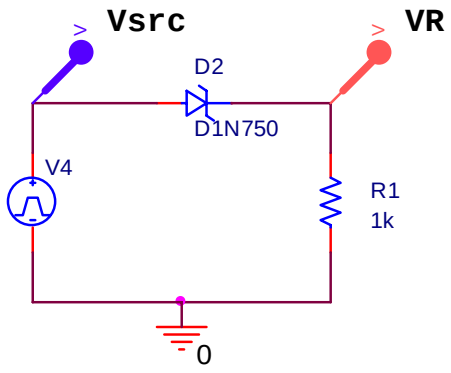
A. Face centered cubic and body centered cubic carbon film.

B. Tantalum diffusion bonded to tungsten.

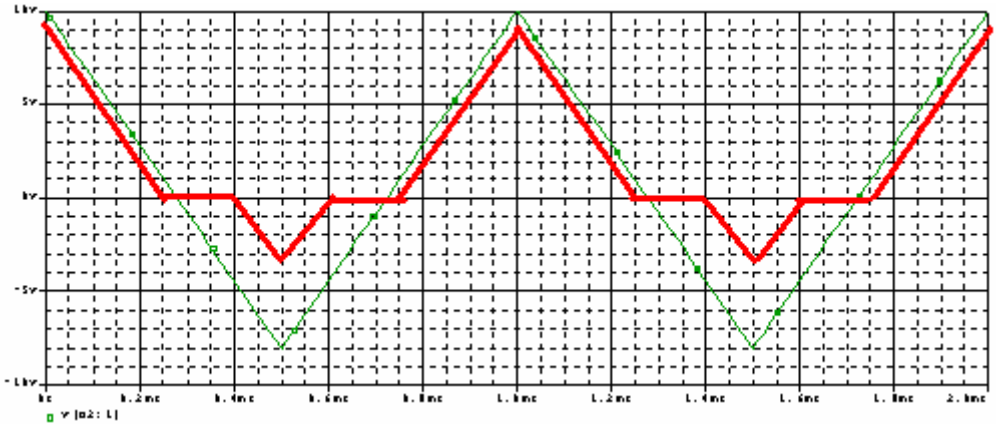
C. Silicon

D. Rare earth super alloys

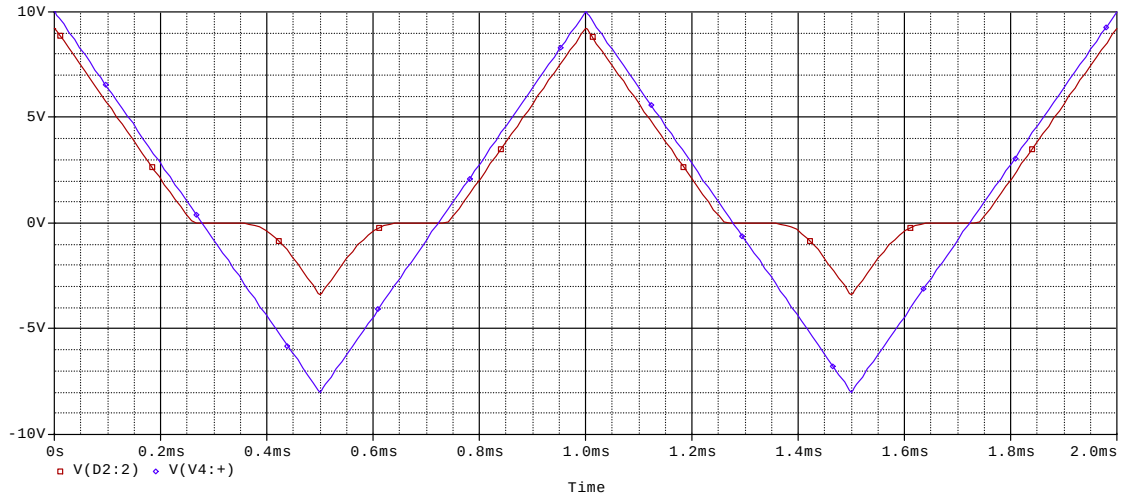
Part B: Zener Diode Circuit



The circuit shown above is excited by the following waveform at V4:



(The theoretical graph has no curvature.)



(The actual graph shows curvature.)

a) Determine Vsrc and VR for the plot shown above at the listed times. [6 points]

Time	Vsrc [½ pt each]	VR [½ pt each]
0ms	***10V***	***10-0.7 = 9.3V***
0.1ms	***6.2V***	***6.2-0.7 = 5.5V***
0.2ms	***2.8V***	***2.8-0.7= 2.1V***
0.3ms	***-0.9V***	***0 V***
0.4ms	***-4.6V***	***0V (maybe a little higher)***
0.5ms	***-8.0V***	***-8.0V-(-4.7)= -3.3V***

b) Sketch the output of the circuit, VR, on the plot of the input shown. [4 points]

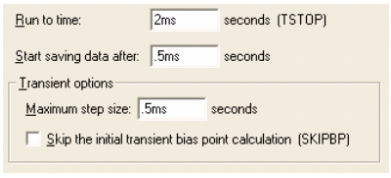
c) What is the (approximate) current flowing in the resistor at: [2 points each = 4 points]

0.9ms: 5.5/1k = ***5.5mA*** *(same as 0.1ms)*

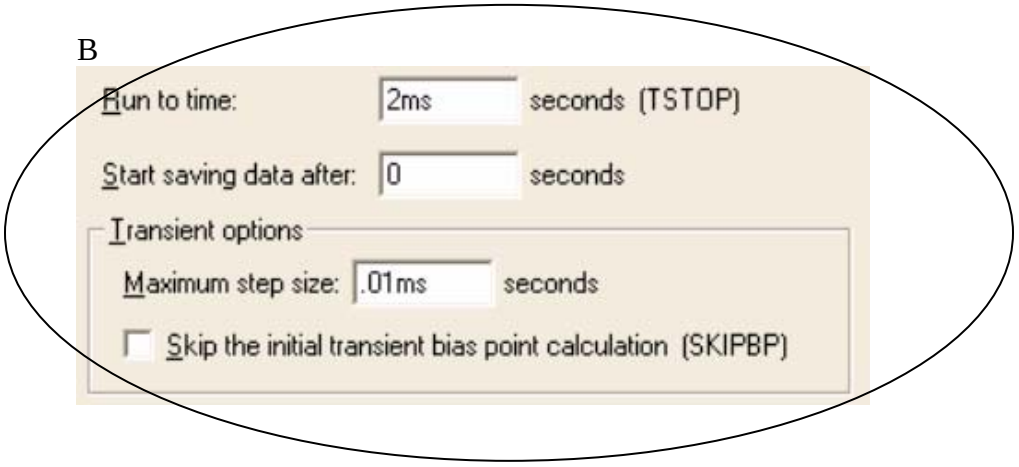
1.3ms: ***0mA*** *(same as 0.3ms)*

d) Which of the following PSpice Simulation Settings would have been used have been used to create this graph? (Circle one) [2 point]

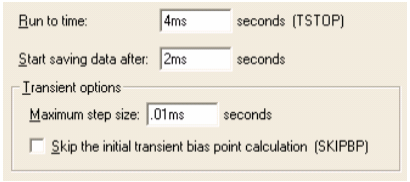
A



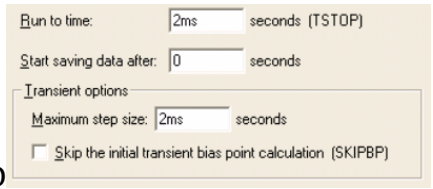
B



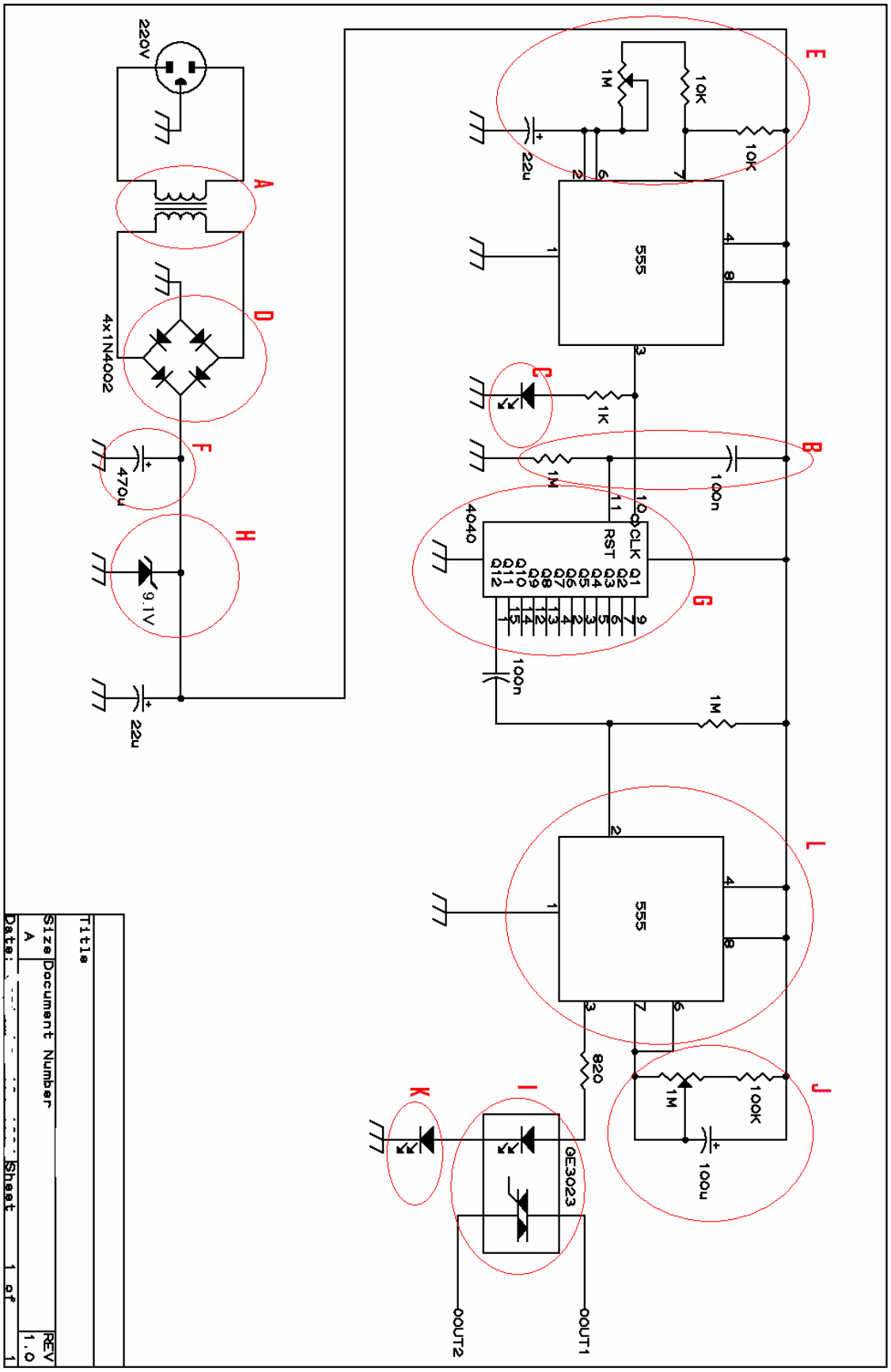
C



D



Question 3 – Circuit Functionality (25 points)



Given the schematic on the previous page, answer the questions that follow. [Hint: Although you have not used every component shown in the circuit, you should have no difficulty inferring functionality based on what you have learned in EI.]

a) What labeled (e.g. A-K) components are part of the power supply sub-circuit? (2 pts)

A, D, F, H

b) What is the source voltage of the circuit? Indicate (AC or DC) and (amplitude or voltage). (2 pts)

220V AC

c) Which device in the circuit uses electromagnetism to provide electrical isolation between different parts of the circuit *and* how is this isolation achieved? (3 pts)

The Transformer block A.
The transformer contains two inductor coils that are allowed to influence each other only through a ferromagnetic material core that they are both wrapped around. A current is run through one coil (the primary coil). It generates a magnetic field (which is magnified by the core material). The magnetic field in the core stimulates a current in the other (secondary) coil. The currents in the two coils are electronically isolated, but the signal is transferred via electromagnetic induction from the circuit on the primary side to the circuit on the secondary side.

d) Does this power supply use a half-wave or full-wave rectifier? (1 pt)

full wave rectifier (block D)

e) What best describes the function of the Zener diode? (circle one) (1 pt)

A) Transistor B) H-Bridge C) Battery

D) Transformer ***E) Voltage Regulator*** F) FM Modulator

f) Which 555 timer is configured in astable mode? (1 pt)

A) The one on the left side of the print C) Neither

B) The one on the right side of the print D) Both

g) Find the on-time of the multivibrator circuit containing the components labeled E, when the resistance of the 1Meg ohm variable resistor 10k ohms. (2 pts)

Ton = .693(10K+10K+10K)(22μ) = ***457.4 ms***
(note that it is charging through all three resistors)

h) Assume the 555 timer is powered with 9VDC, how much current is likely flowing in the LED labeled C? Assume that Von for the LED is 2.1 volts. Show all work. (3 pts)

9V ---- 1kΩ ----- LED ----- GND Voltage across LED (when on) is 2.1V
Voltage across resistor = 9V – 2.1V = 6.9V
I = 6.9/1K

I = 6.9mA

i) Pin 2 of the 555 timer is a: [Hint: Recall where pin 2 (trigger) is connected inside the 555-timer.] (1 pt)

A) Low-impedance input ***B) High-impedance input***

C) Low-impedance output D) High-impedance output

(This pin is connected in the project 3 model to the input to a comparator. Recall that op-amps have very high input impedance.)

j) Assume that when power is first applied to the circuit, all capacitors are discharged. Explain what the R-C circuit labeled B does and how it accomplishes this. [Hint: What is the equation for the behavior of a capacitor? What happens when the circuit is first given voltage? ...once the desired voltage is achieved?] (3 pts)

It supplies an initial reset pulse to the counter at block G.

The equation that governs the behavior of a capacitor is $I_C = C\frac{dV_C}{dt}$. *Initially, the capacitor has zero voltage. As the voltage in the circuit starts to rise to 9V, it generates a current in the capacitor. This creates a pulse that resets the counter to zero. Once the voltage reaches 9V, it stays there, so there is no longer any change and the current through the capacitor becomes zero (open circuit). The reset pin gets connected directly to ground, and the counter (which is no longer being reset) can count.*

k) Assuming that the outputs on the counter (labeled G) are ordered in the same way that the outputs on the 393 counter we used in experiment 7 are, how many pulses has the counter counted when it sends a pulse to the 555 timer labeled L? (3 pts)

This would mean that Q1 is lower order bit.

Q1 goes high at 1 pulse (2^0)
Q2 goes high at 2 pulses (2^1)
Q3 goes high at 4 pulses (2^2)
QN goes high at 2^{N-1} pulses
Therefore, Q12 (output) goes high at 2^{11} pulses

2048 pulses (2047 is ok also)

l) If you decided to build this circuit and found a transformer with a turns ratio of 22:1, assuming other transformer parameters are suitable, would this work to provide our 555 timers with about 9VDC? Justify your answer. Show all work. (3 pts)

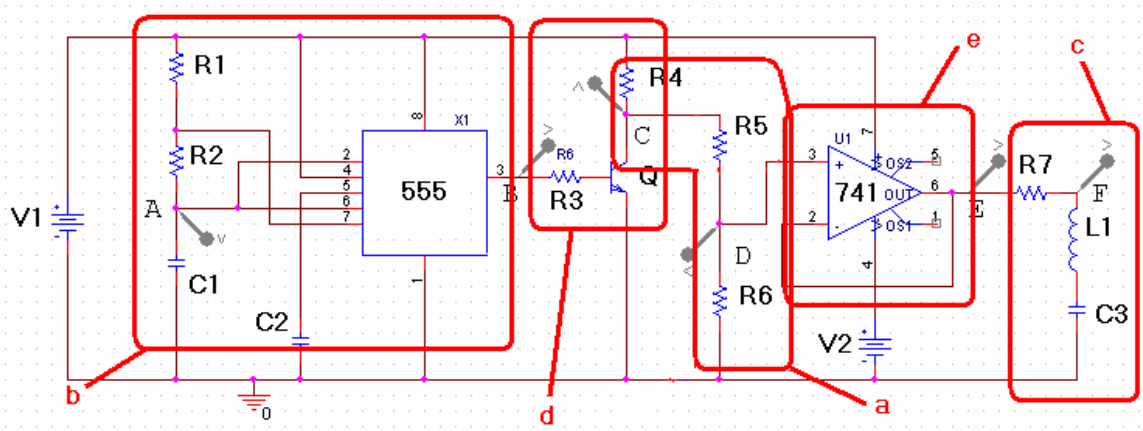
The input is 220VAC. A transformer of 22 to 1 will step the voltage down from 220 to 10V. Therefore, the input to the full wave rectifier will be a 10V sinusoid. The full wave rectifier will rectify the voltage (make it all positive), but reduce the amplitude by an additional 1.4V to 8.6V. The 470μF capacitor is quite large, so it should hold the voltage within a range from 8.6V to just under 8.6V. The Zener diode voltage is 9.1V. The Zener region will never be reached, so it won't be able to regulate the voltage at all.

The circuit will probably work with the 8.6V smoothed input, even though it is not regulated and also not quite 9 volts. Technically, however, this particular transformer will not be able to quite supply the nine volts needed by the circuit.

This question could go either way. If the student decides that 8.6 is close enough, then that is ok. If the student decides that there must be 9 volts and no less, then that is ok also. The justification is more important than the conclusion.

(A transformer of more like 20 to 1 would probably work better. The voltage would be stepped down to 11V. The rectifier would reduce it to 11-1.4 = 9.6 volts. The smoothing capacitor would keep it close to 9.6. The Zener diode would hold it to exactly 9.1 V.)

Question 4 – Ringing Pulse Circuit (25 points)



The circuit above generates a ringing pulse. Assume the components have the following values:

C1 = 0.1μF, C2 = 0.01μF, C3 = 0.068μF
R1 = 1K Ω, R2 = 10K Ω, R3=1KΩ, R4 = 1KΩ, R5=9K Ω, R6=1K, R7=50Ω
R_L (the internal resistance of the fluorescent bulb) varies as the lamp functions.
L1 = 10mH
V1 = +12 V, V2 = -12V

1) Circle and identify the following circuit elements (5 pt)

a. A voltage divider
b. An astable multivibrator
c. An RLC circuit
d. A transistor circuit
e. An op-amp circuit

2) What kind of op-amp circuit is e? (1 pt)

a buffer (or voltage follower)

3) Calculate the frequency of the astable multivibrator in Hertz. (2 pt)

f = 1/ [0.693(R1+2R2)C1]= 1/[0.693(1k+2*10k)*0.1μ] = 1/1.455m
f = 687 Hz

4) Fill in the voltages in the chart below based on the theoretical behavior of the circuit. In the row labeled LOW, give the voltages for all signals when the output at pin 3 of the 555 is low and in the row labeled HIGH, give the voltages for all signals when the output at pin 3 of the 555 is high. Assume all devices have no internal losses. (Give the minimum voltage at point A when pin 3 is low and the maximum voltage at point A when pin 3 is high.) . (10 pts)

Voltage at pin 3	point A (voltage)	point B (voltage)	point C (voltage)	point D (voltage)	point E (voltage)
LOW	***4V***	***0V***	***10.9V***	***1.09V***	***1.09V***
HIGH	***8V***	***12V***	***0V***	***0V***	***0V***

Calculations:

point A: This is the top of the capacitor. It varies between 1/3V1 and 2/3V1.
VA=(1/3)(12) = 4V VA=(2/3)12 = 8V
point B: The output of the timer will vary between VB=V1=12V and VB=0V.
point C: When the output of the timer is low, the switch is open and
VC = 12(R5+R6)/(R4+R5+R6) = 12(10K)/(11K) = 10.9V
When the output of the timer is high, the switch is closed and VC=0V.
point D: When VC is 10.9, VD = 10.9(R6)/(R5+R6) = 10.9(1k)/(10k) = 1.09V
When VC=0, VD=0V
point E: There is a buffer between D and E, so the voltage will be the same on both sides.

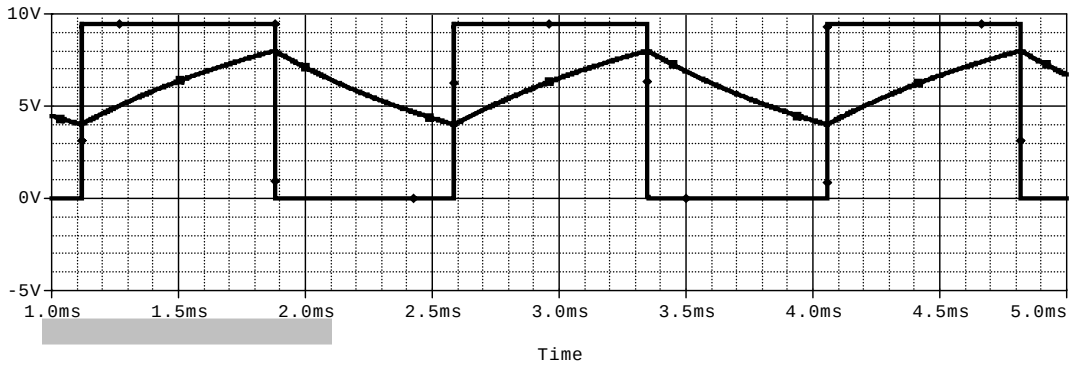
5) Calculate the resonant frequency in Hertz of the signal at F. (2 pt)

$fo = 1/[2\pi\sqrt{(LC)}] = 1/[2\pi\sqrt{(10m)(0.068\mu)}] = 1/.0001638$

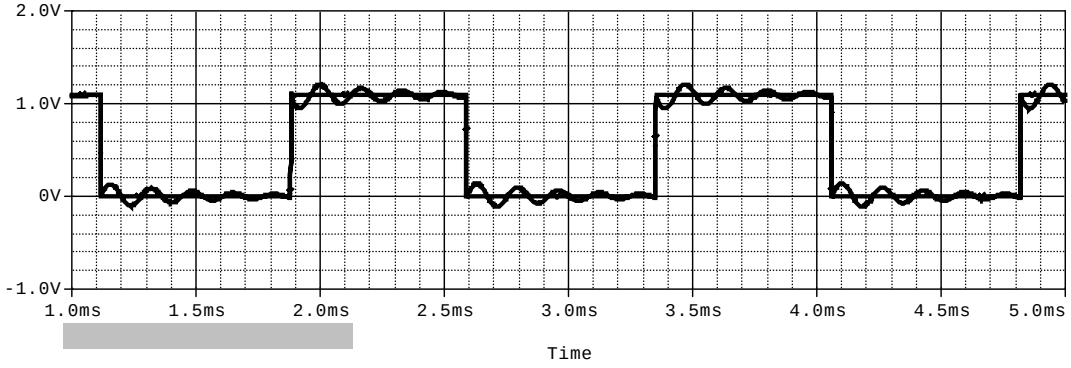
fo = 6103 Hz

6) Identify which of the following plots goes with which block of the circuit (A-B, B-C, C-D, D-E, E-F) All graphs have two signals. [Note: There are voltage losses here that you assumed did not exist in part 4).] (5 pt)

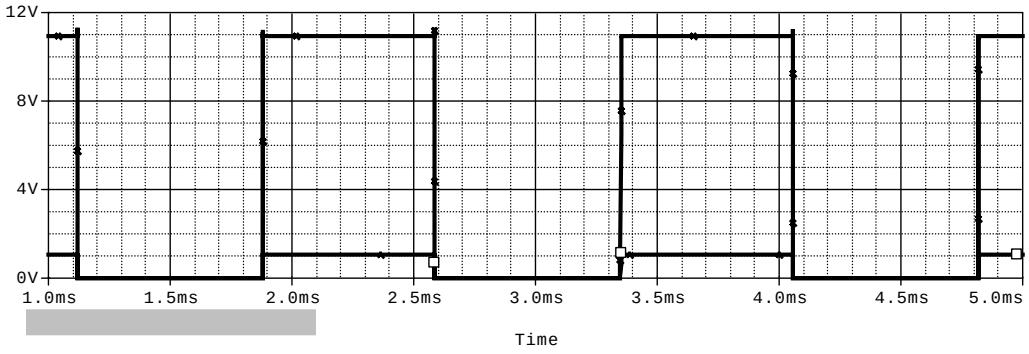
A-B



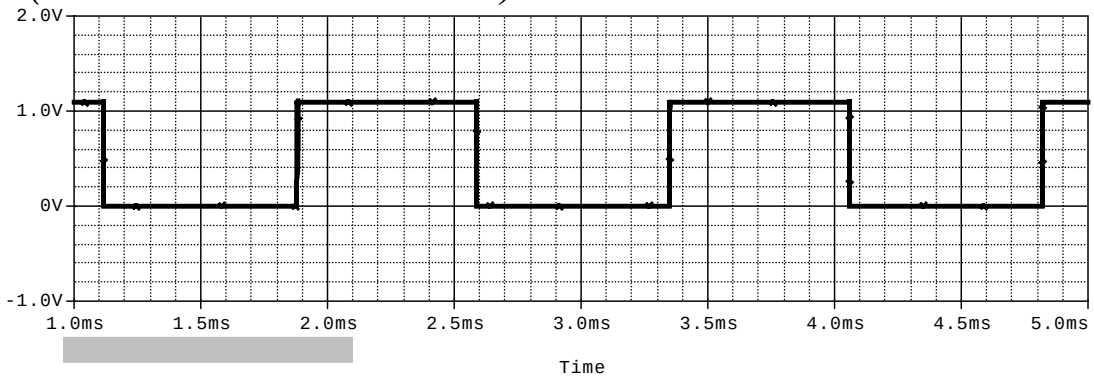
E-F



C-D



D-E *(There are two identical traces here.)*



B-C